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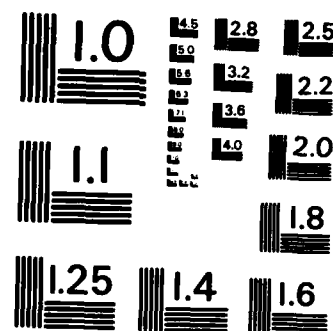
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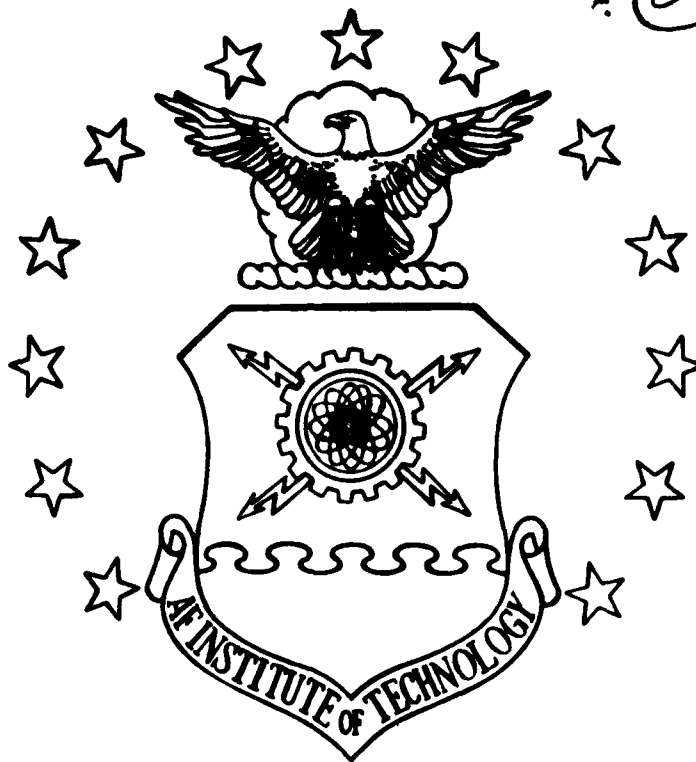
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A PRECIOUS METAL

THESIS

Mary C. Doyle  
Captain, USAF

AFIT/GLM/LSM/85S-20

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A PRECIOUS METAL

THESIS

Presented to the Faculty of the School of Systems and Logistics  
of the Air Force Institute of Technology  
Air University  
In Partial Fulfillment of the  
Requirements for the Degree of  
Master of Science in Logistics Management

Mary C. Doyle, B.A.  
Captain, USAF

September 1985

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Abstract

Acquiring precious metals is an important issue within the Department of Defense when producing and sustaining major weapons systems. Due to precious metal shortages, effective deployment of the national defense preparedness program is in jeopardy in case of serious or continuous national emergency. The overall objective of this research study was to explore and determine the benefits of silver recycling. An extensive literature review was necessary to understand the Defense Logistics Agency Precious Metals Recovery Program. Through extensive research of the Precious Metals Recovery Program, it is evident that there are substantial cost savings which transfer into huge benefits resulting from recycling silver. Precious metals are vital in satisfying the United States' contractual and specification requirements needed for strategic arms, ammunition and equipment. Recycling silver is a valid way of satisfying these requirements.

THE BENEFITS OF RECYCLING SILVER -  
A PRECIOUS METAL

I. Introduction

General Issue

Acquiring precious metals is an important issue within the Department of Defense (DOD) when producing and sustaining major weapons systems. Due to precious metal shortages, effective deployment of the national defense preparedness program is in jeopardy in case of a serious or continuous national emergency. Precious metals are vital to satisfy the United States government's contractual and specification requirements needed for strategic arms, ammunition and equipment. Recycling precious metals is a valid way of satisfying these requirements.

Specific Problem

Precious metals are not found or produced in the United States in sufficient quantities to meet weapons systems production and supply needs. Specific problems associated with acquiring precious metals on the open

market are (a) long lead times, (b) limited production planning, and (c) U.S. heavy dependence on foreign nations as suppliers.

#### Purpose

It was the intent of this research to determine the cost and schedule benefits of recycled precious metals used on defense weapons systems, and to determine whether the benefits of recycled materials supplied as Government Furnished Materials (GFM) are more cost advantageous to the government than acquiring them through open market purchases.

#### Research Questions

1. What are the primary advantages and disadvantages of recycling silver experienced by the government and contractors when using recycled silver processed through the Defense Property Disposal Service (DPDS)?
2. What primary regulations and guidance materials are used to manage and control the recycling process?
3. What are the decision criteria used to select items for silver recycling versus acquiring them through open market purchases?
4. What is the acquisition open market price of silver compared to that of recycling?

5. What are some major contractors served by the DPDS?

6. Are there leadtime benefits of recycling silver versus open market purchases?

### Definitions

The following definitions will be used extensively throughout this report:

Precious metals: The gold, silver and platinum needed to supply military and contractors' needs for Department of Defense of Defense weapons systems.

Government Furnished Materials (GFM): Any item of Government Furnished Property provided to a government contractor for incorporation in the end articles to be produced under the terms of the contract under which are furnished, or otherwise consumed, in the performance of such a contract. These are items which will not be returned to the government in the same state as when provided to the contractor.

Defense Property Disposal Service (DPDS): The organization vested with operational command and administration of the Defense personal property disposal program. Note: Just as this thesis was about to go into final type, a notice was released stating that the Defense Property Disposal Service (DPDS) changed its name to the Defense Reutilization and Marketing Service (DRMS) (17).

Please keep this in mind for future applications and studies of DPDS silver recovery.

Defense Property Disposal Precious Metals Recovery Office (DPDM-R): DLA secondary level field activity that is responsible for the receipt and collection of precious metal-bearing items scrap and waste for processing, consolidation and shipment in preparation for metals recovery and refinement.

Defense Logistics Agency (DLA): Agency responsible for providing, through DLA centers, the most effective and economical support of common supplies and services to the military departments and other DOD components (9:i).

Item: Generic term used to identify the specific entity under consideration. As such, it may be a part, subassembly, group, equipment, etc.

Scrap: Government property discarded for use which, except for its basic material content, appears to have no value. Property that has no reasonable prospect of being sold except for its basic material content.

Open Market Purchases: The act of obtaining silver directly from commercial enterprises at stock market prices.



## Summary

Acquiring precious metals used on defense weapons systems has historically been an important worldwide issue. Recycling is a way of satisfying increasing United States' demand for silver. The purpose of this research project is to determine the cost and schedule benefits of recycling silver.

This thesis documents the execution and results of establishing the benefits of recycling silver. In Chapter I, "Introduction," a general overview of the purpose of this research was given. Research questions were formulated to be used as guidelines for the collection of information. Also, definitions were given to familiarize the reader with basic vocabulary used throughout the research project.

Chapter II, "Literature Review," provides the foundation for this research study. An in-depth discussion is presented to address the problems associated with acquiring silver to highlight the seriousness of obtaining precious metals. The history of DOD silver recycling is then discussed to provide an appreciation of past efforts concentrated on recovering precious metals through DOD property disposal. This chapter also includes a DPDS organization matrix to clarify silver recovery office and personnel responsibilities existing within the Department of Defense. Finally, applicable laws and cognizant

agencies and DOD manuals overseeing silver stockpile goals, and resource exploration and mobilization are discussed to emphasize U.S. government commitment to maintaining precious metals levels.

Chapter III, "Research Methodology," generally explains and justifies the techniques used to determine the benefits of recycling silver, develops a data collection methodology and interview schedules, and identifies interview questions used to provide a basis for analyzing the data obtained from personal and telephone interview responses.

Interview responses regarding actual DOD silver recycling costs are documented and analyzed in Chapter IV, "Analysis and Findings." It also quantifies the benefits received by the U.S. government through recycling silver as opposed to paying the costs of obtaining it through open market purchases.

Finally, Chapter V, "Summary, Conclusions and Recommendations," summarizes the findings for each research question, identifies Precious Metals Recovery Program savings and makes recommendations regarding the scope and direction of future research related to precious metal recovery.

## II. Literature Review

### Precious Metals Acquisition

Research data for this research project was acquired through the Defense Technical Information Center (DTIC), Air Force Institute of Technology (AFIT) School of Systems and Logistics library, the Air Force Logistics Command (AFLC) publications library, and the Wright State University, Ohio library.

There are several problems directly and indirectly associated with the acquisition of critical raw materials and precious metals. Silver is considered a critical raw material and of vital importance in maintaining Department of Defense (DOD) strategic capabilities (14:25). The following is a list of problems, as stated by the Committee on Armed Services Panel, that affect the acquisition of critical and raw materials.

1. The United States is heavily dependent on other nations for the supply of critical materials.
2. The United States does not have an effective national non-fuel minerals policy that promotes U.S. national security interests.
3. The United States government still knows little about the total potential mineral resources of this country.

4. Trends toward excessive and unreasonable government regulations are stifling and crippling the basic mineral industries of the United States; many critical minerals exist in the United States within the 750 million acres of public lands, but because of restrictive laws and regulations, mining is either prohibited or economically unfeasible.

5. The stockpile of strategic and critical materials is woefully inadequate to meet the requirements of the defense industrial base as required by the Strategic and Critical Materials Stockpiling Act (50 U.S. 98).

6. Many of the materials now in strategic stockpile need to be upgraded to forms that will incorporate the maximum energy conversion costs, thereby expediting their use in time of emergency.

7. The United States has not effectively utilized Title III of the Defense Production Act of 1950 (50 U.S.C. App. 2061), which authorizes the government to expand domestic supply and productive capacity of vital resources and to explore for, develop and produce those domestic materials that could relieve the dependence on many uncertain foreign sources. [22:24]

In addition to the panel's findings Cordier notes that highly sophisticated technologies demand a quantum increase of certain key minerals which lead to high capital and schedule costs (5:15).

The many problems that affect the acquisition of critical and raw materials tend to hamper the U.S. government's ability to maintain an effective defense preparedness program in case of national emergency. Although these problems are indirectly associated with silver acquisition, they verify the necessity to recover silver through recycling.

TABLE I  
Silver Consumption Versus Production (6)

	World	United States	U.S. %
Production	364,900,000	40,700,000	(11%)
Consumption	435,800,000	116,800,000	(26%)

As shown in Table I, the consumption of silver in 1981 is greater than the production of that precious metal (2). Based upon these increasing consumption figures, the constant need for the recycling of our precious metal remains to be of paramount importance to the welfare of the United States and its production of major weapons systems. This information further justifies the importance of recycling silver.

#### History of DOD Silver Recycling

Prior to 1972, each DOD service and agency was responsible for recovering precious metals from disposal property. Precious metals were obtained through open market purchases or by recycling disposal property. The primary service managing the Precious Metal Recovery Program (PMRP) was the Department of the Navy. Gold was managed by the Department of the Army, and platinum by the General Services Administration. In 1954, a Navy silver

reclamation program was initiated to recycle scrap torpedo batteries. Between 1954 and 1974, the program was expanded to include the recovery of silver from submarine and missile batteries, x-ray film, photographic paper, used photographic hypo solution, silver-lined bearings, desalting kits, dental materials, electronic equipment, used plating solutions, scrap silverware, and trophies.

In the late 1950s, methods for scrap metal identification became more complex because of the temperature "alloys" used in aircraft and the emergence of various additional uses. Several scrap items and equipment have precious metals in significant amounts, exposed and hidden, which must be disposed of in a manner that best serves the interest of the government (8). In response to the demand for silver, the government established an organization for the primary purpose of managing the disposal of items containing silver and other precious metals -- the Defense Property Disposal Office (DPDO). In 1983, refining was completed by the United States Assay office (USAO) in New York City, and by commercial contractors after the material was blended and evaluated for silver content. Currently, all refining is performed by commercial contractors (6).

The disposal, recycling, and recovery of silver became an important issue of the Senate Permanent Subcommittee on Investigation of the Committee on Government Operations in the early 1970s. The subcommittee investigation, called

the McClellan Committee hearings, began with military supply systems in Europe. One of the primary areas of concern was the lack of an integrated accounting system for the control of property disposal. The existing accounting system was either completely manual or partially mechanized. Each military service and agency maintained separate regulations and procedures to account for property. Subsequently, the Integrated Disposal Management System (IDMS) was developed.

The IDMS is a mechanized disposal property accounting system maintained on the Defense Logistics Services Center (DLSC) computers in Battlecreek, Michigan, for the DPDOS. All world-wide DPDOS are linked to the central computers in Battlecreek via the DOD automatic digital network (AUTODIN) and input to the IDMS on a weekly basis.

In 1974, the GSA assumed overall responsibility for precious metals recovery by all federal agencies. Each civilian agency was responsible for recovering precious metals from the material it generated. This was primarily silver from film and film processing solutions. The DOD consolidated its responsibility under the newly formed Defense Supply Agency (DSA), later redesignated as the Defense Logistics Agency (DLA). The DLA maintained the existing Army and Navy facilities, personnel and procedures until 1978. In 1977, the General Accounting Office (GAO) audited the DOD PMRP and reported to Congress that several millions of dollars were being lost annually. The DOD in fact was losing more precious metals than it was recovering. As a result of this audit, the DOD consolidated its whole program under a new organization called the DOD Precious Metals Recovery Office (PMRO), which is located at the Naval Weapons Station, Earle, New Jersey. . . . All precious metals recovery operations, plans, policies, procedures, etc.,

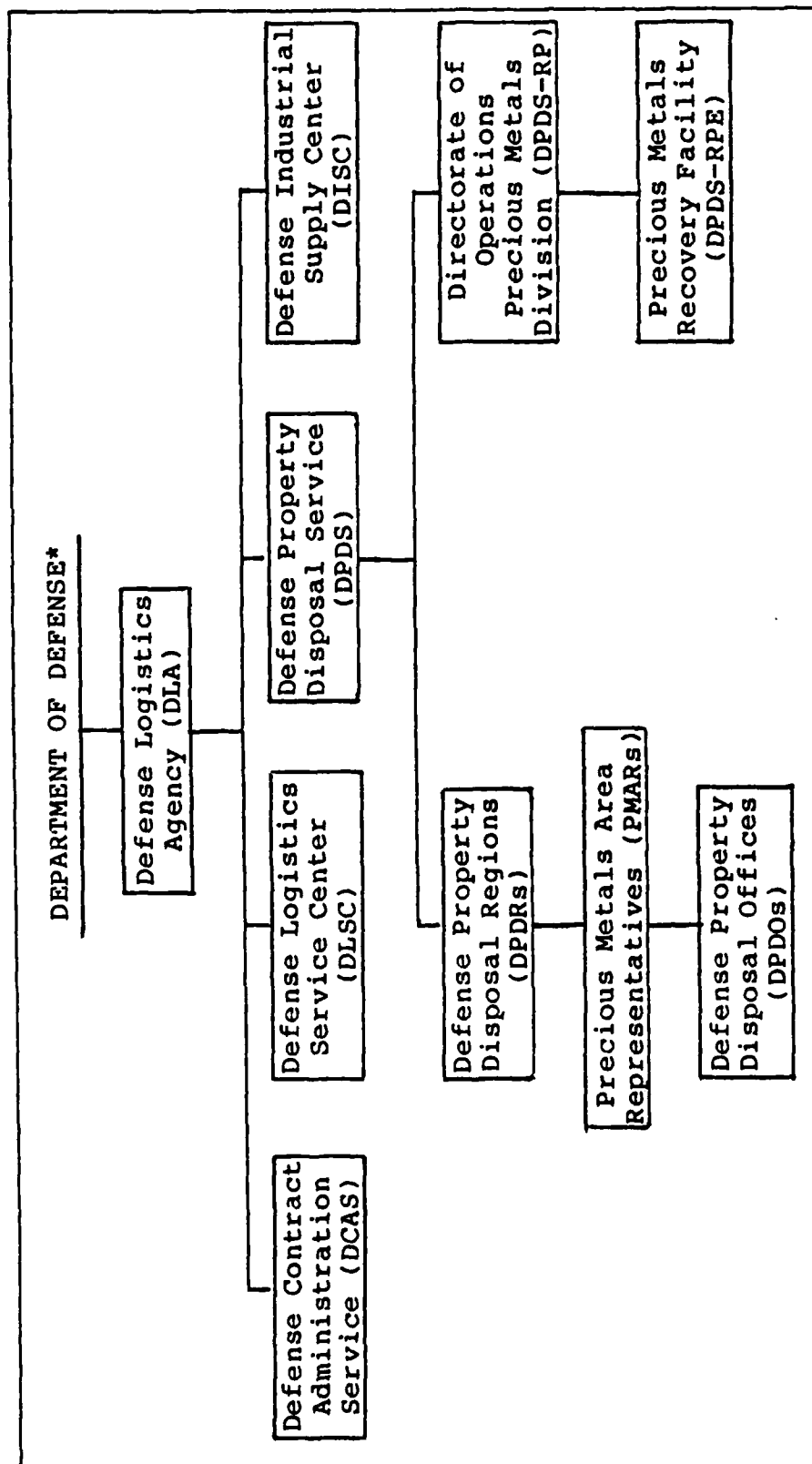
became the responsibility of the new PMRO. . . . Since September 1978, precious metals area representatives (PMARs) have been traveling throughout the U.S. as salesmen for this program. They inform and train DOD personnel in proper identification and handling of precious metals bearing material and assist in the recovery process. Now all precious metals bearing electronic scrap is accumulated for precious metals recovery. [15:8-13]

#### DOD Precious Metals Recovery Program Responsibilities

Currently, the administrator of General Services Administration delegated the responsibility for the disposition of excess and surplus property generated by DOD to the Secretary of Defense. The Secretary of Defense established the Defense Logistics Agency (DLA) to have overall command and management of the Defense Precious Metals Program. One major responsibility of the DLA is to establish or disestablish Defense property disposal organizations and coordinate such actions with the appropriate military service. A general view of the organizations responsible for PMRP management can be seen in Figure 1 (4).

The philosophy and responsibility of the Precious Metals Recovery Program is that each military service promotes maximum utilization of excess, surplus and foreign excess personal property and refined precious metals for internal use or as Government Furnished Material (GFM). Another responsibility is to participate in the Precious Metals Recovery Program (PMRP) by transferring precious metal-bearing material to the nearest collection or recovery activities designated by DLA.





\*Other Federal Agencies may participate through a Memorandum of Understanding with DPDS

Figure 1. Department of Defense Organizations Responsible for PMRP Management

Defense Property Disposal Service (DPDS) responsibilities include managing the centralized operation of the DOD worldwide redistribution system of reported excesses among Military Services/Defense Agencies. Other responsibilities include developing programs for the surveillance of disposal property and related operations to assure optimum reutilization, proper demilitarization and performance of functions. The DPDS organizational structure is illustrated in Appendix A. The DPDS also manages the Defense Property Disposal Regions (DPDR) including the control and distribution of resources and procedures. The DPDS also operates the PMRP and provides staff support (2).

DPDR's responsibilities include operationally supervising the DPDO offices and detachments, and monitoring property accountability. In conjunction with the Defense Property Disposal Precious Metals Recovery Office (DPDM-R), DPDRs monitor DPDO operational aspects (such as equipment maintenance) of the PMRP within assigned geographical areas.

DPDO responsibilities include providing technical assistance to: 1) explain property turn-in procedures, and 2) receive excess surplus, foreign excess, and other authorized turn-ins from service generating activities. The DPDOs inspect and classify property, verify identity and quantity and determine condition and required

processing. In addition, DPDOs promote and ensure maximum conservation of strategic and critical materials including precious metals and influence authorized redistribution/transfer of property to the DOD and other Federal agencies. In conjunction with the DPDM-R, DPDOs supervise precious metals recovery operations of subordinate Property Disposal Holding Activities (such as the Library of Congress at Wright-Patterson AFB OH). Finally, the DPDOs operate silver recovery equipment at assigned central recovery locations. This involves managing supply and maintenance activities, and identifying and recommending repair parts and services required to maximize recovery efforts. DPDM-R also maintains overall responsibility to conduct the PMRP.

The PMRP promotes the economic recovery of precious metals from excess and surplus precious metal-bearing materials and utilization of recovered precious metal for acquisition internal purposes or as GFM. The program encompasses silver, gold and platinum. The DISC is the integrated manager for precious metals and has responsibility for the storage and issue of refined precious metals. Recovery of precious metals to a refined state is accomplished by commercial refiners. In addition, the DPDM-R provides appropriate silver recovery equipment to hypo-generating activities when economically feasible and justifiable. The DPDM-R prepares periodic reports stating

PMRP inventory of unrefined precious metal-bearing material by category and PMRP expenses.

Program Monitor Area Representatives (PMARs) have a very important operational function in silver recovery. Some of their responsibilities include visiting DOD installations in assigned geographical areas to provide technical support, identifying DOD component activities not presently participating in the PMRP with potential for generating hypo solution having silver content, and initiating appropriate action to ensure silver recovery is accomplished. PMARs also estimate average usage of fixer solution and compare recovery potential to actual generations of silver products. The Defense Contract Administration Services (DCAS) conducts pre-award surveys and post-award precious metal recovery contract actions, and administer precious metals contracts in accordance with the terms and conditions of the contract. A partial listing of DPDO precious metals monitors is provided in Appendix B.

Documented Guidance. Research question two asks, "What regulations and guidance materials are used to manage and control the recycling process?" The following information answers this question. The primary manual used to implement the Precious Metals Recovery Program is the DOD Manual 4160.2, "Defense Disposal Manual." This manual was used extensively throughout the literature review to

explain various PMRP responsibilities. DOD Manual 4160.2 is considered the primary DOD guidance for precious metals recovery. Another manual used by the PMRP is AFM 67-1, "USAF Supply Manual." This manual is also used to manage DOD supplies and equipment (2).

### Current DPDS Recycling Processes

The primary recycling process to be reviewed in this research is the process of recovering silver from hypo solutions. The process is explained by the following excerpt from A Layman's Guide to Silver Recovery authored by the X-Rite Company in Grand Rapids, Michigan:

The source of silver is the photographic and x-ray film itself. The emulsion on the plastic film base contains silver compounds. When this emulsion is exposed to light or x-rays, a photochemical reaction occurs creating a latent image. When the film is placed into the developer solution, the exposed areas darken in proportion to the amount of exposure, creating an image. Formation of this image uses only a portion of the total silver available. The balance of the silver must be removed in order to make the exposed image permanent, so the film is then placed into the fixer bath (hypo). Fixer is a solvent for the undeveloped silver compounds and thereby washes them from the film. Developer only produces the image and does not wash off any silver compounds. Silver recoverable from the fixer bath is that silver which has been washed off the light section of the film.

After the film has served its purpose, the remaining silver in the image may be recovered by burning the film and smelting the ashes. [24]

Generally, in photographic and x-ray processing, amounts of high purity silver are generated in fixing

baths. Recovery of silver from spent fixing solution (hypo) can be accomplished by chemical precipitation, metallic displacement and electrolytic methods. Current and potential generators of spent hypo are hospitals, dispensaries, dental clinics, photographic laboratories, printing plants, microfilm and microfilm producing facilities and hobby craft shops (12).

#### Other PMRP Management Agencies

The Defense Industrial Supply Center (DISC). DISC's primary responsibility is to procure refined precious metals from DPDS at recovery cost and provide these metals at recovery cost plus an authorized surcharge (administrative costs, insurance, transportation) for DOD internal uses and GFM. Prices are fixed during the budget execution year. In addition, DISC provides reports on the refined inventory of silver, insures of silver troy ounces and the issue price of silver.

Precious metal item screening, turn-in and processing is a very important step in determining whether it is economical to recover. To illustrate this, an article written by Lt Col Larry J. Goar, USAF, states that historically, the government was losing several millions of dollars due to the non-screening of content and value of items and scrap material. The government was not determining the precious metal content before giving the

material to DOD contractors for refining and processing. Through incorrect processing, negligence, pilferage and fraud, precious metals were probably lost. Because the government material was shipped to the commercial contractor without precise knowledge of its precious metal content, protection or detection of these losses were hard to quantify (15:8-13). As of the date of this research, the government now monitors the commercial contracts for refining precious metals to ensure accurate amounts of silver are returned to the government. The government currently contracts out 100 percent of its refining for silver. In the past five years, the commercial contractor's costs of refining has increased an estimated 8 cents per troy ounce recovered to 21 cents per troy ounce for refining scrap items. Also, Goar's article stated that the U.S. government has the experienced personnel and equipment to refine silver and to avoid contractors while recommending that the government perform this task.

Silver-bearing items are broken down grade by small business subcontractor refiners (to commodity exchange acceptable). The silver is delivered by the subcontractor to the final refining contractor's plant where the silver is refined to a .999 degree of fineness. The DOD contractor, any DOD activity, or any PMRP participating activity or agency may then order material from DISC. Participation is approved by the DLA of the General

Services Administration. When an authorized activity awards a contract that requires GFM silver, the government orders it according to the contract number and the material is credited by the correct account. This is necessary for government auditors to assure adequacy when conducting audits and reviews.

DOD contracting offices contact DISC for current prices and availability of precious metals. If a request for materials is made and the metal is available, the DISC manager logs the request and holds it for 120 days. The 120-day period is necessary to solicit and award contracts. If the requirement exceeds 120 days, the request may be canceled. The reason for this is that DISC does not want to tie up valuable assets in short supply for an extensive period of time.

DISC stores its silver at three locations -- New Jersey, New York, and Connecticut. Yardney Electric stores only silver at its Connecticut facilities. These companies have storage agreements with DISC and have precious metal pool/accounts where assets are transferred into and out of the facility or proper contract account (10). Delivery will normally occur within four to six weeks after receipt of requisition from the refiners unless the metal is transferred into a contractor pool account. Included in the unit price of silver are transportation costs.



According to the DISC, some of the major contractors using recycled silver as GFM are Yardney, and Engelhard and Engelhard Industries (20:11885). The contracts and GFM management are administered by the Defense Contracts Administration Services.

The Defense Contract Administration Service (DCAS). The primary responsibilities of DCAS include performing pre-award surveys and post-award precious metals recovery contractual actions as necessary. DCAS also administers precious metals recovery contracts in accordance with the terms and conditions of the contract and has the responsibility of contracting the recycled silver as GFM.

Federal Emergency Management Agency (FEMA). Executive Order 12155, "Strategic and Critical Materials," created the Federal Emergency Management Agency in 1980. Stockpile goals and procurement schedules for precious metals are determined by the FEMA (18:15-133). After goals are established, defense orders are filled to supply defense contractors and federal agencies. There are several laws that govern priority, allocations and stockpile levels of raw materials (23:55-61).

Department of Commerce. Title I of the Defense Production Act of 1950 seeks to assure adequate supplies are available and authorizes the Department of Commerce to maintain the Defense Materials System. The Defense Material Systems (DMS) is administered by the General

Services Administration to assure that the U.S. maintains the proper levels of specified controlled materials.

The DMS also projects future requirements of controlled materials and assures set-asides for the availability of the acquisition of these materials are established.

The Department of Commerce operates the defense priorities system which ensures that contractors and subcontractors fill high priority items and weapons systems first. The Trade Acts and the Administration Act of 1979 regulates the flow of resources and material during shortages (16:41-47). Each agency must work together as a cohesive group to identify and acquire the critical materials to secure the industrial base. The flow of authority for allocating materials is shown in Figure 2.

### Summary

There are several problems associated with acquiring precious metals. Some problems that affect the acquisition of precious metals, such as long lead times and strict dependence upon foreign nations, apply to commodities such as titanium but do not apply directly to the acquisition of silver. Still, silver is considered to be a precious metal and concentrated efforts by the government must be made to ensure an adequate supply of silver is available. Hence, the availability of silver can be enhanced through recycling.

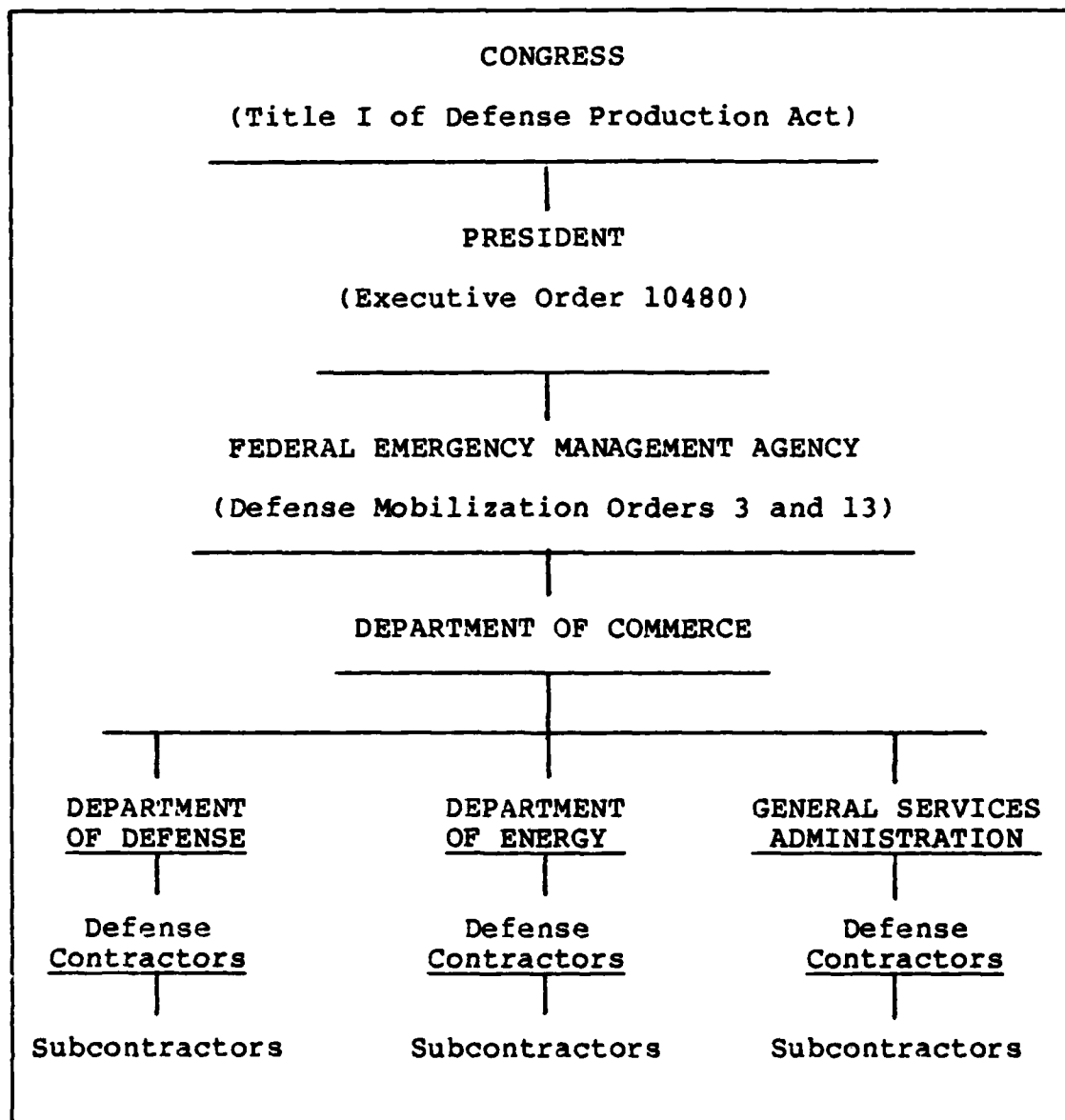


Figure 2. Flow of Authority for Materials Allocation  
(22:56)

In this chapter, hypo-generating, an electrolytic method of silver recovery, was reviewed. Information was examined citing agencies and laws documenting U.S. government production and acquisition policies governing precious metals recovery. The manuals governing the PMRP were identified, providing the answer for research questions two, which asks "What primary regulations and guidance materials are used to manage and control the recycling process?" Various uses of DOD recycled silver can be seen in Appendix C.

The next chapter, "Research Methodology," describes research guidelines and underlying justification for each guideline used to determine key research parameters such as the data collection methodology. Additionally, it describes interview methodology and describes data analysis guidelines.

### III. Research Methodology

#### Introduction

As outlined in the first two chapters of this thesis, the United States is genuinely concerned with the issue of acquiring precious metals in the most efficient and effective manner. Because of the importance of this issue, laws and regulations developed to guide Department of Defense agencies in the recovery of precious metals were documented. The goal of this research effort is to quantify the benefits of recycling silver. To obtain the information necessary to accurately answer the research questions stated in Chapter I, data collection is imperative. Because of the nature of this study -- attempting to determine perceived and intuitive benefits of precious metals recovery -- it was believed that the use of personal and telephone interviews would enhance the probability of collecting clear and accurate responses. Specifically, this chapter discusses the:

- a. data collection methodology
- b. interview data
- c. interview population
- d. data analysis
- e. research limitations

### Data Collection Methodology

The interview technique was chosen for this research effort. One of the advantages of personal interviewing, as stated by William Emory, is "the depth and detail of information that can be secured" (13:292). Therefore, personal interviews were conducted for this research project when feasible. To preclude expenditure of travel funds, interviews were conducted by telephone. As Emory states, "Of all the advantages of telephone interviewing, probably none ranks higher than its low cost" (13:305). Therefore, telephone interviews were conducted with personnel outside the WPAFB facility. These locations were 1) the DPDS in Michigan, and 2) the DISC, located in New Jersey.

Interview Data. Since personal and telephone interviewing techniques were used as a means of acquiring data, prior to each interview the exact purpose, scope and sequence of the interview was communicated to the interviewee. Each interviewee was probed to ensure clear and complete understanding of the intent of the interview. The primary concerns for obtaining data during the development of the interview schedule were 1) to acquire specific cost data associated with recycling silver, and 2) to determine the amount of silver recovered for a specified time period.

Interview data was sought in three general areas and was obtained by 1) examining the recycling decision criteria for actual silver recovery; 2) determining the amount of silver flake turned in to the WPAFB DPDO; and 3) determining the costs associated with silver recovery.

Examining the actual silver recovery process concerns determining which government agency at WPAFB turns in substantial amounts of silver flake. The amount of silver flake turned in to the DPDO provides the researcher a basis for determining recovery costs. Costs associated with silver recovery involve the determination of the amount paid by DPDS for labor equipment, maintenance, supplies, and overhead costs such as transportation and storage fees. Interview questions used to obtain this information is provided in Appendix D.

All interview sessions were conducted either in person or by telephone in the following manner:

1. Each prospective interviewee was initially contacted to determine availability to participate in the research project.

2. Interview appointments were scheduled with PMRP representatives at least one week prior to the respective interview date. The purpose of this was to communicate the scope of interest and to provide the respondent time to prepare responses addressing interview questions.

3. The researcher conducted the interviews and recorded interviewee responses. The researcher concluded by briefly reviewing the data received with the interviewee to ensure the accuracy of each significant response. Finally, a verbal statement of gratitude was given by the researcher to express appreciation for the time and effort expended by the respondent.

Interview Population. The interviewing approach was executed by questioning personnel working within the Precious Metals Recovery Program. Information needed to accurately access the benefits of silver recycling was obtained by interviewing individuals involved in the Defense Property Disposal Service (DPDS). These individuals continuously monitor and report silver recovery and usage.

There are five Defense Property Disposal Regional Headquarters (DPDR), located in Ohio, Tennessee, Hawaii, Utah and West Germany. DPDO operations at Wright-Patterson Air Force Base, Ohio (WPAFB) will be researched. WPAFB is monitored by the DPDR located in Columbus, Ohio and is considered by DPDS personnel as a representative site for researching the benefits received from silver recycling because of the amounts of silver recovered yearly. Located at WPAFB is the Library of Congress, which recycles silver from film processing year-round.



Interviews were conducted with personnel from the WPAFB DPDO, DISC program monitors, the PMAR for the Ohio DPDR, and the manager of the motion picture processing lab at the Library of Congress at WPAFB. Travel costs were minimized by using telephone interviews when personal interviews were not economically advantageous.

For this research project, DOD contractor data were used as a source for acquiring recovered silver usage information about Government Furnished Material. The DOD contractor records examined were chosen from information obtained from Defense Industrial Supply Service (DISC) personnel. The DOD contractors were chosen because of their extensive use of recycled silver.

Interviews were scheduled approximately one week prior to the actual interview. There was no restriction on the length of the interview by the researcher or the respondent.

### Data Analysis

The primary purpose of information analysis is to integrate the data obtained in the information collection phase with stated objectives. To acquire and maintain a rapport with the interviewee, the importance of this research project was communicated in an effort to obtain accurate and complete responses. A sincere interviewing relationship with the interviewee is paramount for

retrieving useful information. In analyzing the data, the researcher will:

1. Briefly explain the silver recycling process performed by the Library of Congress.
2. Determine recycling cost factors by isolating equipment and manhour expenditures used to recycle silver.
3. Determine the current market price of silver by reviewing current silver prices in the Wall Street Journal and any additional cost factors and variables.
4. Accurately determine the benefits of recycling silver versus direct market purchasing. This is accomplished by comparing current market silver prices and recycling costs.

Subsequently, after the information is obtained, the researcher without bias must clarify and interpret interviewee responses and ensure they satisfy research question inquiries. Emphasis will be placed on the direct benefits Department of Defense contractors receive when recycled silver is supplied as GFM.

#### Research Limitations

The precious metal studied in this research is limited to silver, as stated in Chapter I. In addition, the researcher can only study a limited number of weapons systems and/or components to accurately assess specific monetary and schedule benefits of using GFM silver. Due

to the time constraints in preparing this thesis, only a limited number of interviews could be conducted to form the current but valid benefits of silver recycling costs versus purchasing through the open market.

Another important limitation is that the researcher will review silver recovered through use of the electrolytic plating method. There are other recycling methods that can be researched to obtain associated recycling costs. However, the electrolytic method is the only method used by the Library of Congress.

Chapter IV, "Analysis of Findings," synthesizes the results and significant interview responses pertaining to silver recovery benefits.

#### IV. Analysis of Findings

##### Introduction

A total of seven interviews were completed during the period of 30 April to 9 August 1985. Each individual contacted responded to the request for an interview with genuine interest. To exemplify this, one personal interview lasted almost five hours. The length of the telephone interviews generally ranged from approximately twenty to forty-five minutes, depending upon the information requested by the researcher and the degree of interest of the respondent. The exact same questions were not asked of every interviewee because of the different information needed from each PMRP activity. Personal interviews were conducted at Wright-Patterson Air Force Base because the research project originated at that location, thus minimizing travel costs. The length of personal interviews ranged from two to five hours.

The purpose of this chapter is to develop PMRP recycling decision criteria and to show that silver recycling is more cost advantageous to the government than purchasing silver on the open market.

### Recycling Decision Criteria

There are several criteria which must be addressed when determining whether it is advantageous to recover silver from an item. The PMAR insures that appropriate action is taken to recover silver from items and scrap. When material is suspected of containing precious metals, a determination is made through visual inspection, chemical testing, use of the experienced knowledge of DRMS personnel, or by prescribed material identification procedures. After determination is made, material identifications are filed in the precious metals master file (PMMF). The PMMF is a mechanized file identifying precious metals stock number (NSN) items. The PMMF contains over 140,000 items. Research question three asks, "What are the decision criteria used to select items for silver recycling versus acquiring them through open market purchases?" To answer this question, after silver bearing items are turned in to the DPDO, they are processed sequentially as follows:

1. Screened for re-utilization.
2. Offered for sale which reflect the net recovery value of the precious metal count based on current market prices.
3. Sold if projected proceeds reduced by the estimated cost of sale are equal to or exceed the established total recycling and surcharge price.

4. Downgraded and processed for precious metal recovery when it is considered through use of the above computation to not be in the government's best interest to sell the item. Steps outlining decision criteria are shown in Table II. The type and amount of precious metal available in an item is classified by the precious metal indicator codes (PMIC). A list of PMIC codes is provided in Appendix E.

Criteria for deciding whether to recycle precious metals scrap is provided by determining whether the number of troy ounces contained in the scrap multiplied by the current market price of silver produces a value greater than the associated recovery/refining cost, thus justifying precious metal recovery. This procedure answers research question three, "What are the decision criteria used to select items for silver recycling versus acquiring them through open market purchases?"

The Library of Congress film laboratory was chosen as the site for monitoring silver recovery operations. The scrap generated from film processing was processed through electrolytic methods (3). Currently, all refining is performed by government prime and subcontractors. The semi-annual direct cost of silver flake is estimated and shown in Table III (7).

From January through June 1985, the Library of Congress at WPAFB has turned in 29,859 grams of silver

TABLE II

Silver Recovery Decision Criteria Steps (11)

AFTER ITEMS ARE TURNED IN TO THE DPDO:

ITEMS ARE SEQUENTIALLY:

1. SCREENED FOR REUTILIZATION
2. OFFERED FOR SALE VERSUS RECOVERY DETERMINATION
3. SOLD IF PROJECTED PROCEEDS EXCEED TOTAL RECYCLING  
AND SURCHARGE PRICE, OR
4. PROCESSED FOR SILVER RECOVERY SCRAP WHEN  
ACCUMULATED FOR PMRP AND SENT TO REFINING:
  - (1) DETERMINED IF ECONOMICAL TO RECYCLE
  - (2) SENT TO DISC IF ECONOMICAL, OTHERWISE  
SCRAP IS DISPOSED

TABLE III

## Library of Congress Semi-Annual Silver Recovery Costs

Item	Cost	Hours
1. Supplies: Test Paper Collection Containers Cartridges Fittings Control Valves Parts	\$ 50.00	
2. Equipment (Electrolytic Unit) Initial Cost (Amortized for 5 years)	\$ 40.00	
3. Initial Installation of Equipment	\$ 24.00	4 hours
4. Maintenance: Cleaning Adjusting Fuses Gaskets	\$1,040.00	130 hours
TOTAL	\$1,154.00	134 hours
Average Cost	\$1,154.00	
At Basic Recycling Stage	960.10/TO	= \$1.20/TO



flake to the DPDO. By using the conversion factors in Appendix F, 29,859 grams of silver convert to approximately 960.10 troy ounces of silver (1). Associating the semi-annual costs in Table III, the direct cost of silver recovery is approximately \$1.20 per troy ounce. This does not include transportation, security and storage fees from the source (the Library of Congress) to its final destination, the DOD contractor or government office. DPDS overhead billing records for 1984 were not available from DPDS or DISC at this time because the DLA has been incorporating revised cost reporting procedures in an effort to improve billing consistencies generated from regional offices. Therefore, the researcher was not able to identify individual overhead cost amounts. However, the issue price to DOD contractors is \$2.32 per troy ounce.

DISC reports that the current total billing cost of silver recycling is \$1.83 per troy ounce, plus an additional 21 percent administrative surcharge (\$.49). These costs are equal to the current issue price of \$2.32 to DOD contractors (10). The silver open market price of \$6.13 on 24 July 1985 was used to compare the cost per troy ounce of recycling silver (22). Of course, in real world transactions, open market prices of silver will vary according to market fluctuations. The current silver open market price (\$6.13 per troy ounce) and the recycling issue price of \$2.32 per troy ounce satisfies the information

required to answer research question four, which asks, "What is the acquisition open market price of silver compared to that of recycling?" In this case, the decision process of choosing items and scrap for recycling involves a \$3.81 per troy ounce savings over the market price as of 24 July 1985. This information completes the decision criteria used for the final decision of whether to recycle silver-containing items.

There are several DOD and contractual uses for the recycled silver. Some uses of silver for DOD contractors as well as DOD departments include use on engine parts and aerospace radiation sheets (see Appendix C).

Research question five asks, "What are some major contractors served by the DPDS?" Two major contractors using recycled silver are Yardney Industries and Engelhard Industries, which both manufacture batteries for the Navy MOCK 45 torpedoes. Other recycled silver is supplied to contractors for use in the production of Air Force desalting kits, Army PAC Man radio batteries, and NASA space shuttle piping systems.

To illustrate the amount of recycled silver used by DOD contractors, DISC supplied Yardney Industries with 873,492 troy ounces of silver as GFM from October 1984 through June 1985. As shown in Table IV, the estimated savings to the government were \$3.3 million (6).

TABLE IV  
DOD Total Savings - Yardney Industries

Date	Issues Per Troy Ounce	Cost Savings/ Troy Ounce	TOTAL
October-December 84	254,418		
January-March 85	292,500		
April-June 85	326,575		
TOTAL	873,492	\$3.81	\$3,328,008.30

Hence, savings are realized with the use of PMRP recycled silver versus use of silver acquired through open market purchase. Additionally, the military services use recycled silver in their operations. The Air Logistics Centers make use of recycled silver in their maintenance operations.

DCAS notifies DISC of the prospective contractual requirements for GFM silver six to eight weeks prior to its scheduled use. Research question six asks, "Are there leadtime benefits of recycling silver versus open market purchases?" From the information received from DISC regarding silver delivery and usage by contractors, there appears to be no significant leadtime benefits apparent when DOD contractors acquire GFM-supplied silver.

The reported contract savings from use of recovered silver totaled almost \$200 million for FY75 through FY83. Savings per year are presented in Table V. To increase total U.S. government cost savings, DOD employees, contractors and legislative agencies must make concentrated efforts toward finding and exploring new and even more cost effective methods of recovering precious metals. The approximate \$200 million savings can be considered a primary advantage for recycling. There are no significant disadvantages to recycling. This information answers research question one, which asks, "What are the primary advantages and disadvantages of recycling silver experienced by the government and contractors when using recycled silver processed through the Defense Property Disposal Service (DPDS)?"

#### Summary

There are several factors that must be considered when deciding whether to recycle items and scrap containing precious metal. Some of these factors are refineries, transportation, rent, utilities, direct labor and equipment costs. Other factors include the proper identification of silver-bearing items and scrap and the proper scheduling and delivery of silver commodities.

Examining the recycling process cost data from the Library of Congress resulted in a cost breakout of each

TABLE V

## Total PMRP Silver Recovery Savings (6)

<u>Fiscal Year</u>	<u>Savings in Millions \$</u>
1975	\$ 8.6
1976	16.4
1977	13.1
1978	12.2
1979	20.7
1980	60.8
1981	20.5
1982	20.9
1983	25.9
TOTAL	<u>\$ 199.1</u>

major cost factor from the actual recycling state to its final re-use destination. Sample uses of recycled silver used in DOD contracts and the corresponding cost savings resulting from this research is shown in Table V and VI, respectively.

This chapter answered research questions one, three, four, five and six. Research question one asks, "What are the primary advantages and disadvantages of recycling silver experienced by the government and contractors when using recycled silver processed through the Defense Property Disposal Service (DPDS)?" This question was answered by identifying the primary advantage of silver recycling as cost savings to DOD contracts. There were no significant disadvantages evident from this research study.

Research question three asks, "What are the decision criteria used to select items for silver recycling versus acquiring them through open market purchases?" This question was answered by reviewing turn-in and processing documents governing silver recycling procedures. Also, the per-troy-ounce total PMRP savings resulting from recycling can be considered a major input to the decision of whether to recycle items.

Research question four asks, "What is the acquisition open market price of silver compared to that of recycling?" This question was answered by stating the current troy ounce price of silver based on figures from the Wall Street

Journal (22). Recycling costs were based on Library of Congress film laboratory direct costs and DPDS estimated overhead costs.

Research question five asks, "What are some major contractors served by the DPDS?" To answer this question, names of contractors using GFM supplied silver were acquired from Defense Industrial Supply Service personnel.

Research question six asks, "Are there leadtime benefits of recycling silver versus open market purchases?" In this research there were no significant leadtime benefits identified. Based on the contract data examined, there were no leadtime problems identified as long as GFM silver is requested six to eight weeks prior to use.

This research identified cost savings to DOD contracts as the primary advantage of using recycled silver. However, an additional advantage is the efficient and effective use of a natural resource.

Chapter V, "Summary, Conclusions and Recommendations," highlights total PMRP savings information obtained from this chapter and states conclusions arrived at by examining information obtained through this research project. Additionally, specific areas of follow-on research are recommended.

## V. Summary, Conclusions and Recommendations

### Summary

Silver recovery is a dynamic field of study with past, present, and future benefits necessary for the promulgation of Department of Defense major weapons systems. The decision to recycle items and scrap is not a "cut and dried" task, but a well thought-out process with corresponding benefits.

In Chapter I, the specific problem regarding the urgent need for the United States to acquire precious metals in an expeditious and economical manner was identified. The use of recycled silver as a solution to expanding government supplies of natural resources was identified. To identify the methods and organizations for maintaining silver stock levels, a literature review was performed.

Chapter II examined literature that clearly identifies historical and current problems of attaining precious metals while citing several areas where these commodities can be accumulated for use on Department of Defense (DOD) weapons systems. Literature was reviewed to examine applicable U.S. laws and regulations that provide for silver and other precious metal recovery. Finally, the organization and responsibilities of the Precious Metals



Recovery Program (PMRP) were reviewed to get an overall view of the DOD silver recovery process. Information in this chapter answered research question two, which asks, "What primary regulations and guidance materials are used to manage and control the recycling process?"

Chapter III explained the research methodology used in obtaining information necessary for conducting this research. This involved an extensive research on existing literature, and conducting personal and telephone interviews with personnel who work within the Precious Metals Recovery Program.

In Chapter IV, decision criteria used by the PMRP managers to recycle silver were examined. Direct costs of the Library of Congress were identified and totaled.

The research questions answered were:

1. What are the primary advantages and disadvantages of recycling silver experienced by the government and contractors when using recycled silver processed through the Defense Property Disposal Service (DPDS)?
2. What primary regulations and guidance materials are used to manage and control the recycling process?
3. What are the decision criteria used to select items for silver recycling versus acquiring them through open market purchases?
4. What is the acquisition open market price of silver compared to that of recycling?

5. What are some major contractors served by the DPDS?

6. Are there leadtime benefits of recycling silver versus open market purchases?

To answer these research questions, recycling versus market costs were compared to indicate the cost savings/benefits of silver recycling. In addition, the primary advantages and disadvantages of silver recycling were examined. To summarize, information from this chapter answered research questions one, three, four, five and six. Research question two was answered in Chapter II.

### Conclusions

The overall objective of this study was to explore and determine the benefits of silver recycling. An extensive literature review was necessary to understand the DLA Precious Metals Recovery Program. Through extensive research of the Precious Metals Recovery Program, it is evident that there are substantial cost savings which transfer into huge benefits resulting from recycling silver.

As a result of this review it was found that, although the current property disposal manual contains general procedures for recycling, it is outdated and in need of revision (1). The film recycling process at the Library of Congress film laboratory, located at Wright-Patterson

AFB, was found to be consistent with the property disposal manual. Currently, final silver refinement is done by commercial contractors instead of refinement by the Government Assay Office, as mentioned in the manual. This type of inconsistency exemplifies the need for revision of the "Defense Disposal Manual."

### Recommendations

In response to Lt Col Goar's article recommending that government personnel refine precious metals, as referenced in Chapter II, this researcher is in agreement with Lt Col Goar's position. From the many interviews conducted for this study, there are several competent and experienced personnel working in the Precious Metals Recovery Program. Setting up government refining facilities for the silver recovered can be accomplished with government capital investment. New facilities require considerable investment initially, but based upon the savings generated yearly from the PMRP, the expense would be worthwhile. The refining control should be put back into the hands of the government.

DOD Manual 4160.21, "Defense Disposal Manual," primarily used as precious metal recovery basic procedure guidelines, is outdated and currently under revision (1). According to DPDO personnel, since the present manual was completed in 1979, it does not reflect current practices

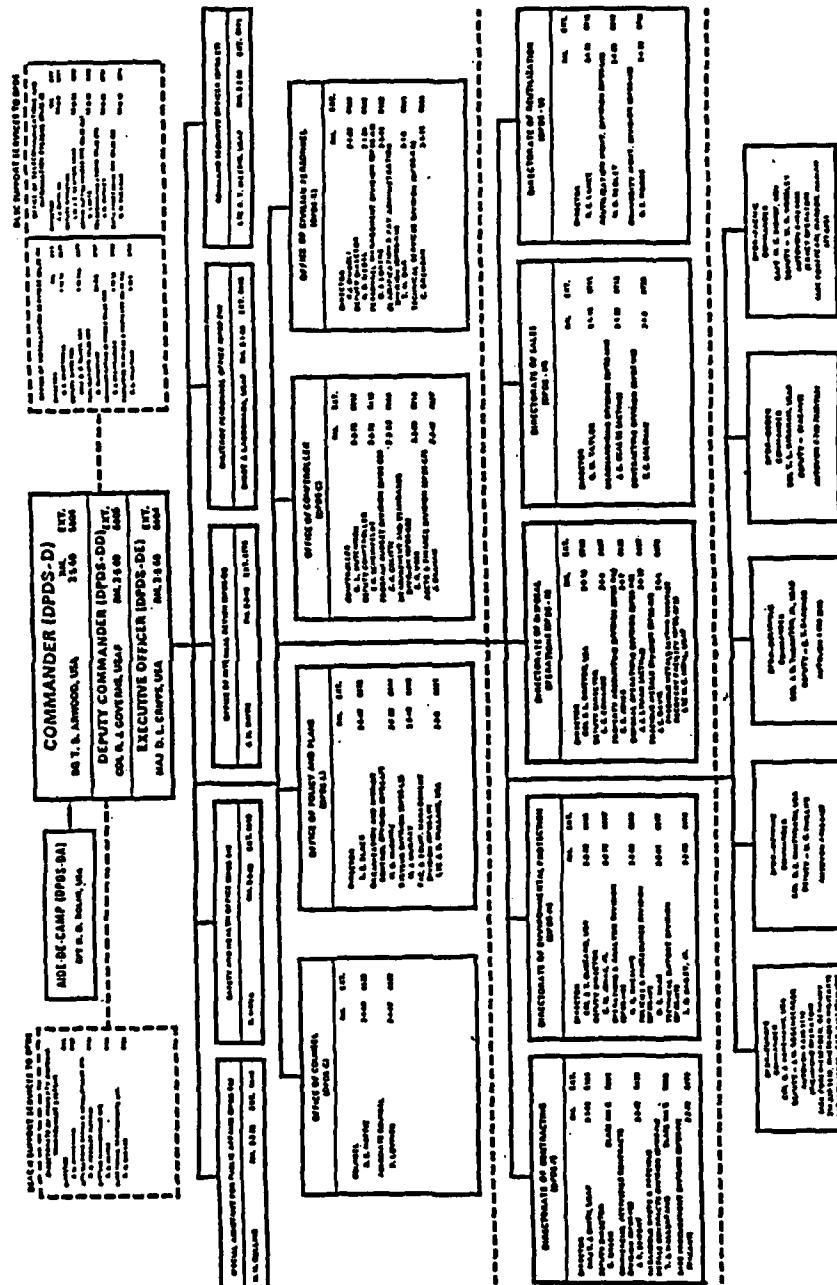
within the PMRP. Although the revision was to be completed this year there have been delays, and no estimate of the completion date could be obtained. Until this revision is completed it may be difficult to accurately describe the DLA recovery program. Completion of the revision will be very helpful for anyone interested in learning more about the silver recovery process.

A recommendation arising from this research project is that the PMRP managers should actively emphasize how much money is being saved on DOD programs, thus presenting a strong economic posture to the public and government employees. The Precious Metal Recovery Program has exhibited a positive image, and the government should openly take credit for this image.

Recommendations for further investigation and study are:

1. Research should be undertaken to determine the present and historical costs of refining silver through commercial contractors.
2. A determination should be made whether the U.S. government should establish its own facilities for refining DPDO items and scrap material.
3. The benefits of recycling other precious metals such as gold and platinum should be studied.
4. An extensive survey of government contractors should be conducted to determine how recycled materials are used.

## Organizational Structure



Appendix B: Partial Listing of DPDO Monitors

<u>LOCATION</u>	<u>NAME</u>	<u>COMMAND</u>	<u>OFFICE SYM</u>	<u>PHONE</u>
Plattsburgh NY	TSgt R. L. Waters	SAC	LGSP	689-3837
	ALT: SMSgt Leavitt		LGSP	689-3838
	ALT: TSgt Ochs		LGSD	689-7386
Pope NC	SSgt Jones	MAC	317 TAW/LGSPS	486-4167
Ramstein AB GE	TSgt Phillips	USAFE	86 TFW/LGSP	480-3688
	ALT: SSgt Youngblood			
Randolph TX	SMSgt Howard	ATC	LGSCS	487-2743
	ALT: Maj Windham		LGSP	487-5124
	SMSgt Beagle		64 FTW/LGSPM	838-3876
Rhein Main GE	Maj John Bierle	MAC	433 TAW/LGX	330-7147
San Vito Del Normanni IT	TSgt Boggs	USAFE	7275 ABG/LGSP	622-3555
	ALT: MSgt Schwehr			
	ILt Jones		375 AAW/LGX	638-3513
Scott IL	Maj Taylor	USAFE	601 TCW/LGSP	496-7456
Sembach AB GE	ALT: SMSgt Marsh			496-7243

Appendix C: DOD Uses for Silver

Department	Use
Aerospace	Radiation Shield Communications/Electronics
Medicine	Dentistry X-Ray Arthritis Membrane Repair
Aircraft	Processing Equipment Brazing Engine Parts Panels Alloys Structural Parts
Architecture	Windows Insulation
Electronics/ Electrical	Cable Contact Points, Solder Circuit Boards Control Panels Magnetos Spark Plugs Automatic Data
Personal Apparel	Uniform Buttons Decorations Eyeglass Frames

## Appendix D: Sample Interview Questions

Question	Interview Question
1	Which office decides to recycle an item or scrap metal?
2	How is film recycled?
3	How often is silver recycled and subsequently turned in to the DPDO?
4	How many man or machine hours are needed to recycle a gram or troy ounce of silver?
5	What are the initial costs of silver recycling (electrolytic) machines?
6	What are the standard maintenance costs of electrolytic converters?
7	Are there any silver recycling offices at Wright-Patterson AFB OH?
8	What are the primary regulations governing silver recycling?
9	Are the regulations under revision?
10	How much silver flake is turned in yearly from the Library of Congress?
11	Explain the complete cycle of film recycling until finally providing GFM to the contractor or government agency.
12	Are there any current organizational charts available that accurately represent DPDS and the Library of Congress?
13	What are some of the major contractors who use GFM on DOD weapons systems?
14	How much does the contractor/government pay for GFM?
15	How long does it take to receive GFM after it is requested?
16	What are some of the current uses of silver supplied as GFM?
17	Are the grades of silver available as GFM adequate to satisfy our defense needs?
18	What are some of the improvements that can be made within the DPDS?



Appendix E: Precious Metals Indicator Codes

Code	Type Precious Metal and More/Less than Contract
A	No known precious metals.
B	Item is known to contain precious metal(s) but amount is unknown.
C	Presence or absence of precious metals varies between items of production for the same item of supply.
D	Silver - Equals 15 grams or more.
E	Silver - Less than 15 grams.
T	Silver/Gold - Combination equals 15 grams or more.
U	Silver/Gold - Combination less than 15 grams.
V	Silver/Platinum Family - Combination equals 15 grams or more.
W	Silver/Platinum Family - Combination less than 15 grams.
X	Silver/Gold/Platinum Family - Combination equals 15 grams or more.
Y	Silver/Gold/Platinum Family - Combination less than 15 grams.

Appendix F: Frequently Used Conversion Factors

Weight		Factor		Weight
Pounds, AVDP	x	14.583	=	Troy Ounces (TO)
Pounds, AVDP	x	453.590	=	Grams (Gm)
Pounds, Troy	x	12.000	=	Troy Ounces (TO)
Troy Ounces	x	31.100	=	Grams
Kilograms	x	1000.000	=	Grams
Pounds, AVDP	x	2.200	=	Kilograms (Kg)

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### Vita

Captain Mary C. Doyle was born on 30 October 1956 in Los Angeles, California. She graduated from Westchester High School in California in June 1974 and attended Loyola-Marymount University in Los Angeles, from which she received a Bachelor of Business Administration degree in 1978. She subsequently earned a commission from Officer's Training School in November 1979. She attended Systems Acquisition training at Lowry AFB CO while concurrently working as a Cost and Schedule Specialist at the Air Force Plant Representative Office from November 1979 to July 1983. Captain Doyle served approximately one year as a buyer at Space Division in California before entering the School of Logistics, Air Force Institute of Technology, Wright-Patterson AFB OH in May 1984.

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Acquiring precious metals is an important issue within the Department of Defense when producing and sustaining major weapons systems. Due to precious metal shortages, effective deployment of the national defense preparedness program is in jeopardy in case of serious or continuous national emergency. The overall objective of this research study was to explore and determine the benefits of silver recycling. An extensive literature review was necessary to understand the Defense Logistics Agency Precious Metals Recovery Program. Through extensive research of the Precious Metals Recovery Program, it is evident that there are substantial cost savings which transfer into huge benefits resulting from recycling silver. Precious metals are vital in satisfying the United States' contractual and specification requirements needed for strategic arms, ammunition and equipment. Recycling silver is a valid way of satisfying these requirements.

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